

Geometry of historical epoch, the Alexandrov's problem and non-Gödel quantum time machine

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Abstract. The new quantum principle of a time machine that is not using a smooth timelike loops in Lorentz manifolds is described. The proposed time machine is based on the destruction of interference of quantum superposition states in the Wheeler superspace.

Keywords: time machine, no-Gödel principle, historical epoch, gravitational waves, Wheeler superspace

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It is known [1, 2], that the classical space-time M^4 is the result of quantum interference occurring in the Wheeler's superspace due to quantum superposition

$$\Psi(M^4) = \sum_{k \in K} c_k \Psi(\Omega_k), \quad c_k \in \mathbb{C}, \quad (1)$$

$$\Psi(\Omega_k) = A_k \left(\begin{array}{c} \text{slowly varying} \\ \text{amplitude function} \end{array} \right) e^{-\frac{i}{\hbar} S_k({}^{(3)}\mathcal{G})},$$

$$S_k = S_{k'} = \dots = S,$$

where a wave function $\Psi(\Omega_k) = \Psi_k({}^{(3)}\mathcal{G})$ is a functional of 3-dimensional Riemannian geometry ${}^{(3)}\mathcal{G} = (M^3, h_{\alpha\beta})$ and satisfies the functional Wheeler-DeWitt's equation:

$$\left(G_{\alpha\beta\gamma\delta} \frac{\delta}{\delta h_{\alpha\beta}} \frac{\delta}{\delta h_{\gamma\delta}} + \sqrt{h} {}^{(3)}R - \mathcal{E}(h_{\alpha\beta}, \mu, B, e, \sigma, \nu) \right) \Psi_k({}^{(3)}\mathcal{G}) = 0.$$

Here $S_k({}^{(3)}\mathcal{G})$ is an action that satisfies to the Einstein-Hamilton-Jacobi equation

$$G_{\alpha\beta\gamma\delta} \left(\frac{\delta S_k}{\delta h_{\alpha\beta}} \right) \left(\frac{\delta S_k}{\delta h_{\gamma\delta}} \right) - \sqrt{h} {}^{(3)}R + \mathcal{E}(h_{\alpha\beta}, \mu, B, e, \sigma, \nu) = 0.$$

1. A historical epoch

Usually, one does not discuss the meaning of the system Ω and its states Ω_k , $k \in K$, which have the wave function $\Psi(\Omega_k)$. In [3] we suggested that state Ω_k is a *real* historical epoch, which is relatively stable, unchanging, constant in all senses including the geometry of 3-space, i.e. the stable time period of the existence of human civilization. These historical epochs "without time" were described as Gestalt by Wolfgang Goethe and specially Oswald Spengler in "Der Untergang des Abendlandes".

The 3-geometry ${}^{(3)}\mathcal{G}$ of historical epoch Ω_k *knows* its *time location* in 4-geometry of space-time: "the hypersurface drawn through spacetime to give one ${}^{(3)}\mathcal{G}$ can be pushed forward in time a little here or a little there or a little somewhere else to give one or another or another new ${}^{(3)}\mathcal{G}$. "Time" conceived in these terms *means* nothing more or less than *the location of the ${}^{(3)}\mathcal{G}$ in the ${}^{(4)}\mathcal{G}$* . In this sense 3-geometry is a carrier of information about time" [2, p. 37].

Thus, we can say that space-time is the result of the quantum interference of historical epochs. The Minkowski postulate of *absolute World of events*, or absolute space-time should be replaced by following postulate: *The World*

exists in the form of historical epoches. So, we can make the transition in each historical epoch.

The most important fact of quantum theory is observation, and that the interference pattern disappears when one trying to measure the state of quantum system Ω . In our case, this means that the beginning of procedure of geometrical measurement, i.e. switching on of apparatus that fix the particular geometry ${}^{(3)}\mathcal{G}'$, which took place in the past, one inevitably destroys its locally interference pattern.

In fact, let $|k\rangle$ be a state of historical epoch Ω_k with wave function $\Psi_k({}^{(3)}\mathcal{G})$ of quantum system Ω , which is described by superposition

$$\sum_k c_k |k\rangle.$$

Let an observer X is living in epoch Ω_{α_0} . Then geometrical measurement that is produced by observer X with the help of apparatus \mathcal{A} with initial state A and aimed at specific value of 3-geometry ${}^{(3)}\mathcal{G}'$ which is geometry of past historical epoch $\Omega_{k'}$, give the new superposition:

$$\left(\sum_k c_k |k\rangle\right) \otimes |A\rangle \rightarrow \left(\sum_{k, k \neq k_0, k'} c_k |k\rangle\right) \otimes |\tilde{A}\rangle + (c_{k_0} |k_0\rangle \otimes |A_0\rangle + c_{k'} |k'\rangle \otimes |A'\rangle).$$

We see that two epoches $\Omega_{k_0}, \Omega_{k'}$ form the entangled states with apparatus (environment). The others epoches form the interference quantum superposition, giving classical Universe.

Historical epoches exist *at the same time*, or *simultaneously*. External observers are not out of this quantum superposition, and within own historical epoch for which this own historical epoch seems true objective reality. From the epoch Ω_{k_0} the observer X makes the observation of packet (1). This packet makes collapse and some spatial volume of $\Omega_{k'}$ is localized in the epoch Ω_{k_0} . As a result, apparatus together with the observer X will be in Reality which is past historical epoch $\Omega_{k'}$, i.e. apparatus together with the observer will enter to past. In other words, we have mechanism called the *time machine*.

2. The Gödel time machine

In the General relativity the time machine refers to the return mechanism in the past, suggested in 1949 famous logician Kurt Gödel. The *Gödel time machine* suggests that the transition in the past makes the apparatus, world line of which is a closed time-like smooth curve.

In 1968 Soviet academician A.D. Alexandrov formulated the the problem of founding of the physical conditions under which one is possible to transition in a past historical epoch [4, 5]. But he considered then the only known mechanism of the Gödel time machine. Therefore, the Alexandrov problem is limited the study of Lorentz manifolds in which exist a closed smooth time-like curves.

Situation with solving of the Alexandrov problem is given in [5, 6].

It was natural to try to leave the General relativity in its classic version, i.e. within the framework of classical physics, and to use the ideas of quantum theory. The idea of using quantum interference for transitions in time was first described in the article [7].

3. The non-Gödel quantum time machine

Our project that we set out at the beginning of this note is also a quantum time machine. Described the transition in the past is probabilistic. The required historical epoch can not be achieved at all times. The full description of this project to be soon published in [8].

The transition in past epoch is done by measuring of the geometry (and not only geometry, because quantum theory also uses observers, i.e. the moments of human consciousness). We understand very well how to measure the geometry. Within the ideology of the General relativity the measurement of geometry is the measurement of gravitational fields. Every historical epoch can be regarded as a gravitational wave with fixed parameters, detection apparatus of which is more or less developed.

A certain kind of activity (measurement) of observers from epoch Ω_{k_0} with respect to values, that are typical only for the epoch $\Omega_{k'}$, destroy the entanglement with the last remaining epochs, and is linked these two epoches. This measurement localizes each epoch into another. There will be a transition from epoch to another. This is nothing other than a time machine. Since another epoch have my quantum double (this is as another location of one particle), then murder him does not mean murder themselves. In other words, the grandfather paradox is solved trivially.

But the problem of measurement of geometry is not easy one. Wheeler wrote: "The formalism of quantum gravity, in its best developed form, makes 3-geometry a central concept; consequently, the finding of a proper way to measure this 3-geometry – against the background of the indeterminacy of the conjugate geometrodynamical field momentum – is a central issue" [9, p. 231].

Since $|\Psi(\Omega_k)|^2$ is the probability density, then we must assume that histor-

ical epoch has the most probable geometry of ${}^{(3)}\mathcal{G}$. For the fixing of specific geometry, one should be adjusted instrumentation. Perhaps it is not just measuring apparatus, but devices which give the "resonance" with geometry of the historical epoch that we are interested through the generation of gravitational waves *or others fields* [10, 11].

But "tuning equipment" to the desired geometry, perhaps is only first step. Quantum mechanics is strongly related to the consciousness problem [12], and historical epochs are not empty geometric worlds, but are worlds inhabited by people, and therefore historical epoch is also the energy of ethnic groups, political passion, and more. The geometry is need people to live, and quantum interference patterns are destroyed not only due to the measurements, but also because of the intentions to make such measurements.

4. The quantum time machine in minisuperspace

The Wheeler-DeWitt equation for minisuperspace which is defined by a homogeneous and isotropic Universe (compact spatial topology, $k = 1$)

$$ds^2 = N^2(t)dt^2 - a^2(t)dl_{S^3}^2$$

with a massless scalar field ϕ and $a = e^\alpha$, $\alpha \in \mathbb{R}$, has the following form

$$\left(\frac{\partial^2}{\partial^2 \alpha} - \frac{\partial^2}{\partial^2 \phi} - e^{4\alpha} \right) \Psi(\alpha, \phi) = 0. \quad (2)$$

We impose the boundary condition

$$\lim_{\alpha \rightarrow 0} \Psi(\alpha, \phi) = 0 \quad (3)$$

necessary in order to reconstruct semiclassical states describing the dynamics of a closed Universe, since regions of minisuperspace corresponding to arbitrary large scale factors are not accessible.

It should be noted that the considered scalar field ϕ most likely to be regarded not as matter, but as a collective energy of people which create the universe [13, 14].

The problem (2)–(3) has the following solution [15] in the form of wave packet

$$\Psi(\alpha, \phi) = \int_{-\infty}^{+\infty} A(k) \Psi_k(\alpha, \phi) dk, \quad (4)$$

where

$$\Psi_k(\alpha, \phi) = e^{-k\frac{\pi}{4}} \sqrt{k} K_{ik/2} \left(\frac{e^{2\alpha}}{2} \right) e^{ik\phi}, \quad (5)$$

$$A(k) = \frac{1}{\pi^{1/4} \sqrt{b}} e^{-\frac{(k-\bar{k})^2}{2b^2}}. \quad (6)$$

The solution represents a wave packet that starts propagating from a region where the potential vanishes (i.e. at the initial singularity) towards the potential barrier located approximately at $\alpha_{\bar{k}} = \frac{1}{2} \log \bar{k}$, from where it is reflected back. For such values of \bar{k} the wave packet is practically completely reflected back from the barrier. The parameter b gives a measure of the semiclassicality of the state, i.e. it accounts for how much it peaks on the classical trajectory. We remark that the peak of the wave packet follows closely the classical trajectory,

$$e^{2\alpha} = \frac{\bar{k}}{ch(2\phi)}. \quad (7)$$

and refer the reader to Fig. 1, b).

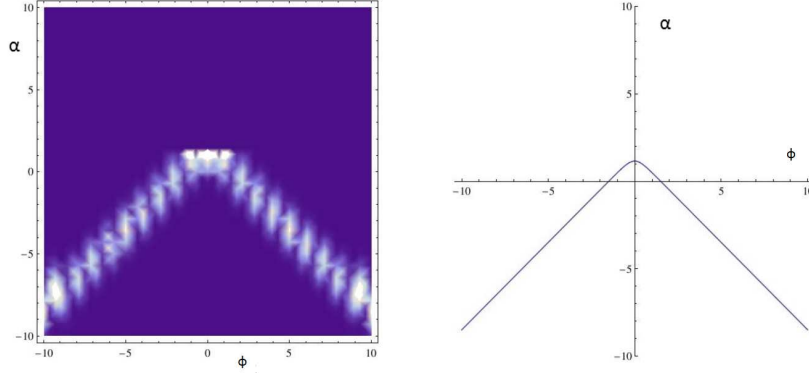


Figure 1: a) Absolute square of the wave function of the Universe corresponding to the choice of parameters $b = 1, \bar{k} = 10$. Lighter shades correspond to larger values of the wave function; b) Classical trajectory of the Universe in minisuperspace. It is closely followed by the peak of semiclassical states, as we can see by comparison with a). [15]

Under measurement we have a collapse of considered wave packet

$$\int_{-\infty}^{+\infty} A(k) \Psi_k(\alpha, \phi) dk \rightarrow \Psi_k(\alpha, \phi)$$

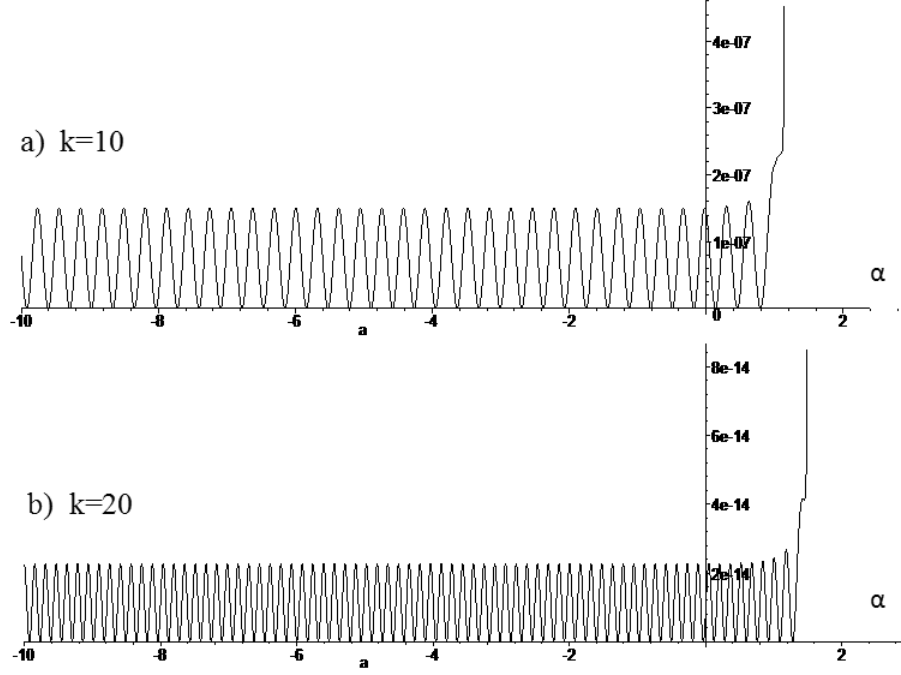


Figure 2: Graph of $|\Psi_k(\alpha, \phi)|^2$ for $k = 10$ and $k = 10$.

with probability $|A(k_0)|^2$.

Consider the graphs at Fig. 2 of geometric epoches Ω_{k_0} for $k_0 = 10$ and $k_0 = 10$.

We see that historical epoch Ω_{k_0} can have a number of different geometries. But a geometry with $\alpha > 0.4$ will be most probable for Ω_{10} and with $\alpha > 0.6$ for Ω_{20} . But what is important: geometry $\alpha < 0.4$ is much less likely for Ω_{20} than for Ω_{10} . Although transition to geometry with $\alpha < 0.4$ is practically impossible. The differences in the behavior of the probability density functions of various historical epoches give the opportunity to adjust the measuring equipment so that to get to the desired epoch.

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